MODULATING A POLYCHROMATIC IMAGE BY A 2ND IMAGE PLOTTED AGAINST SATURATION AND A 3RD IMAGE PLOTTED AGAINST LIGHTNESS – PROGRAM hlsplot

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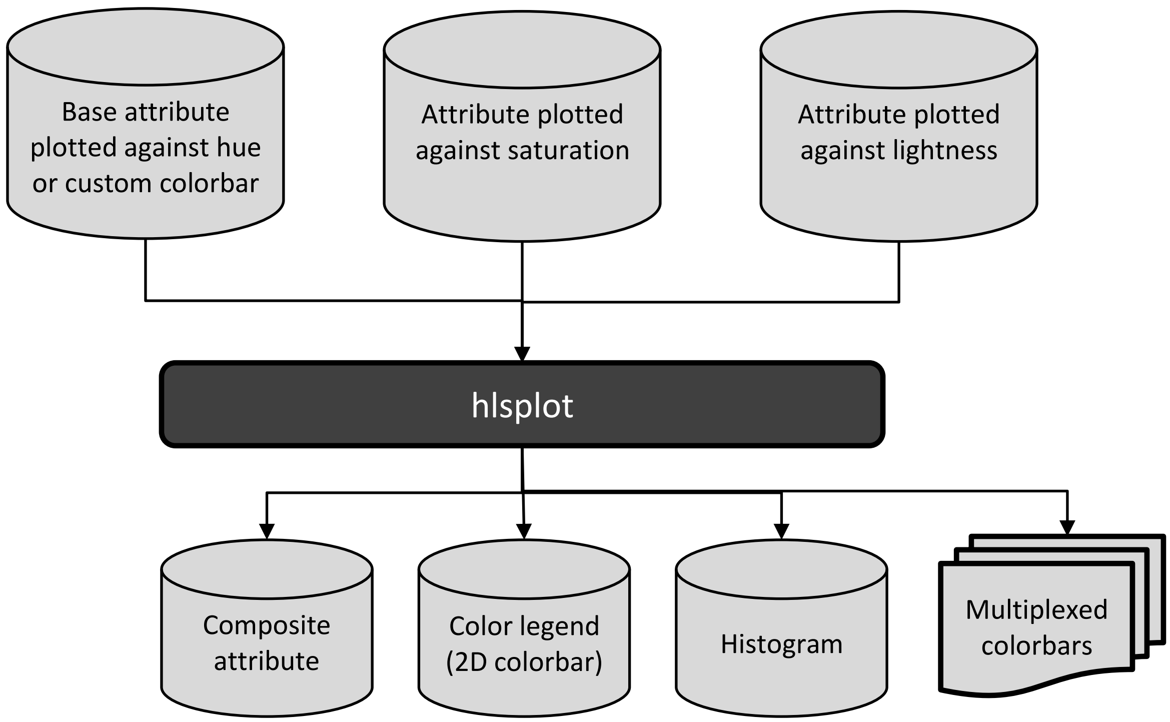
Overview

There are two main reasons to modulate one attribute by another. The first application is when the two attributes form components of a 2D vector such as dip magnitude and dip azimuth, envelope and instantaneous phase, or spectral peak magnitude and spectral peak phase, whereas the third is the original seismic amplitude. The second application is when we wish to modulate an attribute vector or an attribute crossplot by another that provides a measure of confidence. For example, we may wish to map volumetric dip azimuth and magnitude by coherence.

The AASPI software allows several ways to do this. Program **hlplot** modulates an attribute plotted against a polychromatic color bar by a second against lightness. Program **hsplot** modulates an attribute plotted against a polychromatic color bar by a second against saturation. Program **hlsplot** allows two levels of modulation. Program **corender** provides an interactive means to modulate one attribute by one or two others.

Computation Flow Chart

Program **hlsplot** reads in three attribute volumes and outputs a composite volume, a color legend, a histogram, and a suite of multiplexed colorbars that can be used to load the composite volume into the more common interpretation workstations software products.



Output file naming convention

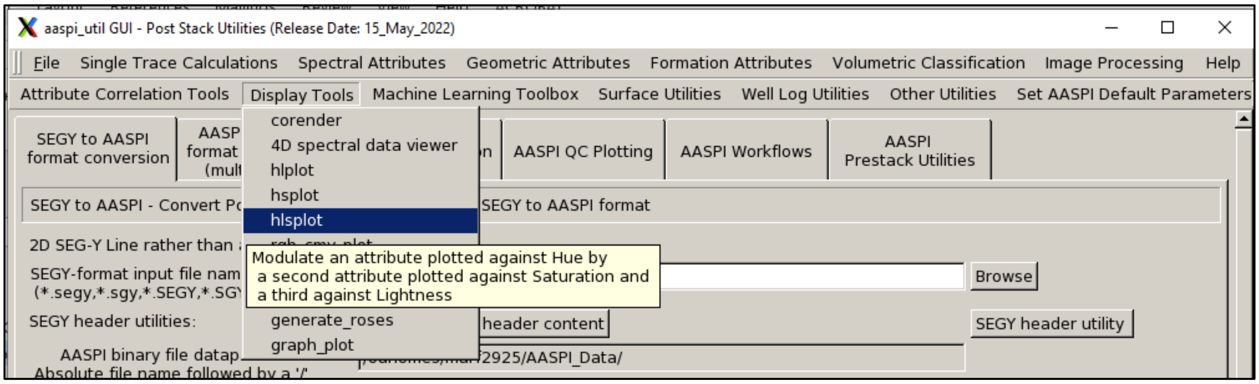
Program **hlsplot** will always generate the following output files:

Output file description	File name syntax
Composite attribute	*Hue_axis_title*_vs_*saturation_axis_title*_vs_*lightness_title_unique_project_name*.H
Color legend (2D colorbar)	hlsplot_color_legend_*hue_axis_title*_vs_*saturation_axis_title*_vs_*hue_axis_title_unique_p*
2D histogram	hlsplot_histogram_*hue_axis_title*_vs_*saturation_axis_title*_vs_*hue_axis_title_unique_proj*
Multiplexed 1D colorbars	hls_colorbar.alut, hls_colorbar.CLM, etc
Program log information	hlsplot_*unique_project_name*.log
Program error/completion information	hlsplot_*unique_project_name*.err

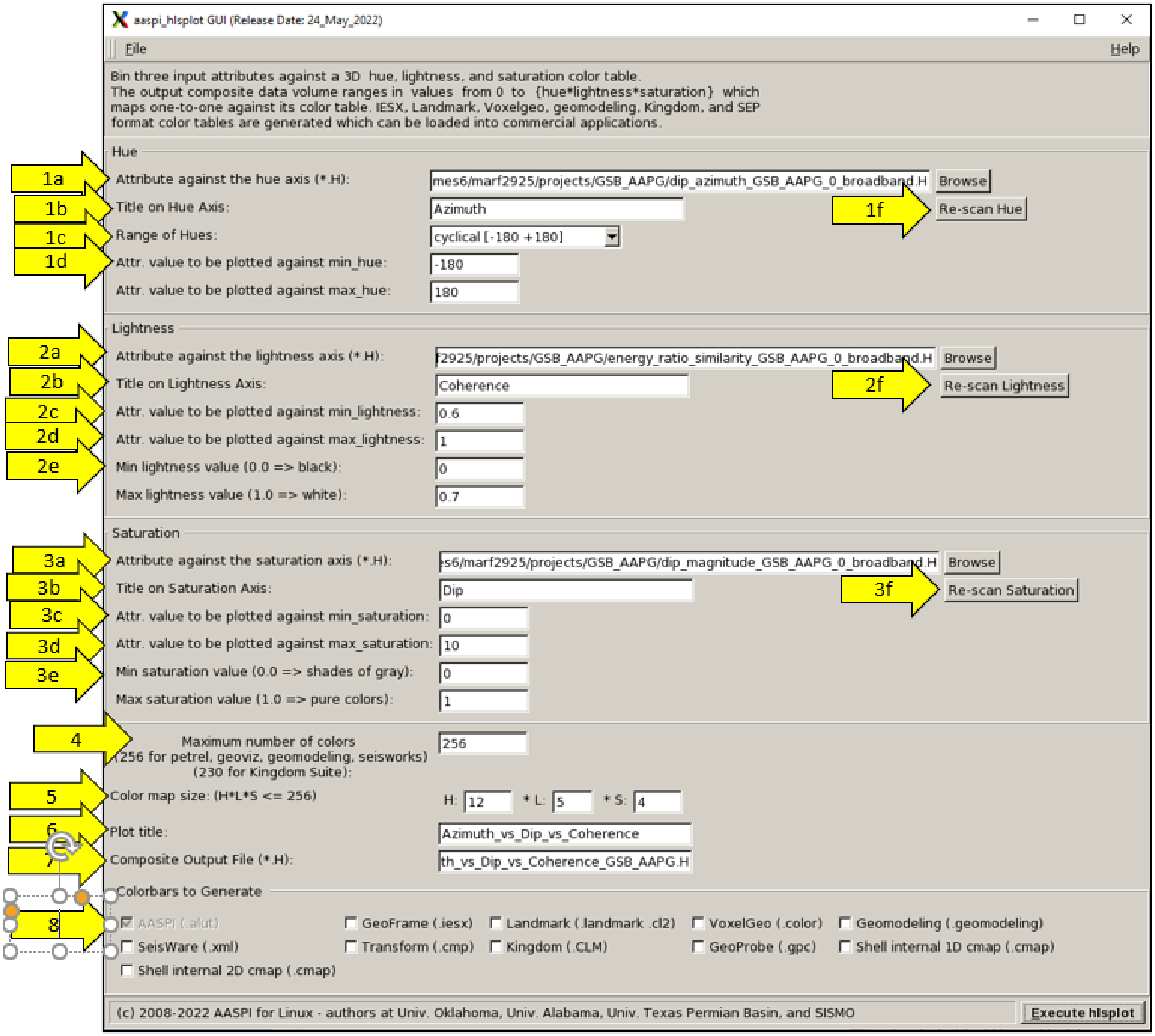
where the values in red are defined by the program GUI. The errors we anticipated will be written to the **.err* file and be displayed in a pop-up window upon program termination. These errors, much of the input information, a description of intermediate variables, and any software trace-back errors will be contained in the **.log* file.

Invoking the hlsplot GUI

To invoke program **hlsplot**, on the **aaspi_util** GUI select *Display Tools* and then select **hlsplot** on the drop-down menu:

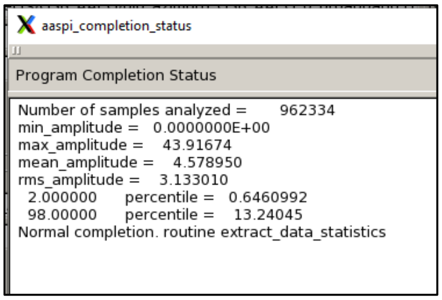


The following GUI opens up:



Mapping the attributes against the H, L, and S axes

Program **hlsplot** plots one attribute against hue (H), a second attribute against lightness (L), and a third attribute against saturation (S). Enter the names of three files to plot against (1a) hue, (2a) lightness, and (3a) saturation. The title of each axis (1b, 1c, 1d) will default to that of the input files. These axis titles will be combined to construct a (6) plot title, and with the unique project name from the hue file the name of the (7) composite output file. Depending on your axis titles you may wish to shorten them for conciseness and/or clarity. The range of the attributes (1c,1d,2c,2d,3c,3d) will be read from the minimum and maximum attribute values on each of the files. In general, azimuth and phase should range from -180° to +180° and strike from -90° to +90° even if the data do not contain all those angles (e.g., a consistent regional dip to the SE). For the lightness axis, coherence ranges from 0 to 1. I changed the default to be 0.6 to 1. For saturation, the default is to range between 0° to +90°, however, I know my data has few strong dips. To better understand the statistics of the data I click (3f) *Re-scan Saturation*, and obtain the following pop-up window:



where I see the data range between 0° and 43.9° with the 2nd and 98th percentile at 0.6° and 13.2°. I therefore set my limits (3c and 3d) to be 0° and 10°.

In general, you should not need to change the mappings 1d, 2d, and 3d, unless you want to reverse a given color axis.

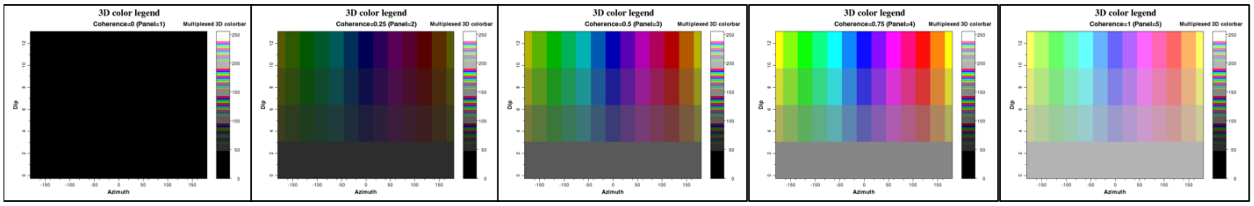
Defining the 3D color map and color depth

The more commonly used commercial software have been established for over a decade. For this reason, most are limited to using no more than 256 colors in a given image (Kingdom Suite only allows 240 colors, with the remaining 16 used for picks and legends). Through opacity and/or RGB blending (as in AASPI program corender) many of these packages can allow 256×256=65,536 or even 256×256×256=16,777,216 colors, although the associated color tables are not explicitly created. Using more colors to define the same range of colors is referred to as *color depth*.

For the example above, I use the default (5) *Color map size* of 256. I use the default parameters of (5) *nhue*=12, *nlightness*=5, and *nsaturation*=4, giving a total of 240 colors. The remaining 16 colors will be set to white, which will also serve as a background color for dead traces and mute zones. I click *Execute hlsplot* and wait for a suite of images to appear.

The 3D color legend

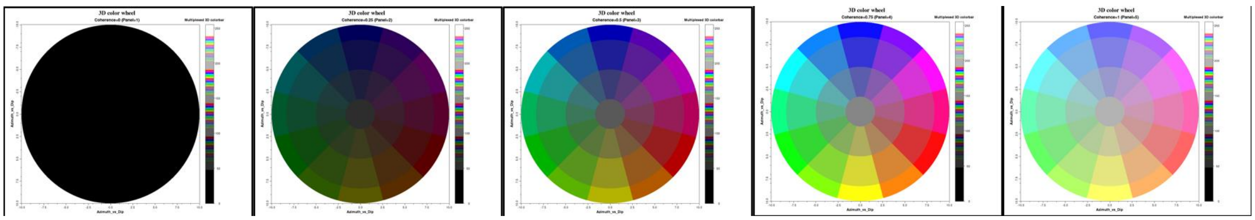
First, the 3 color axes are plotted against each other in a rectangular volume. Here, I display the five panels corresponding to coherence values of 0.6, 0.7, 0.8, 0.9, and 1 which range from black, through midnight colors, through "pure" colors, to pastel colors. If the maximum value of lightness was set to 1.0, the last panel would be white, thereby making all dip and azimuth values look the same.



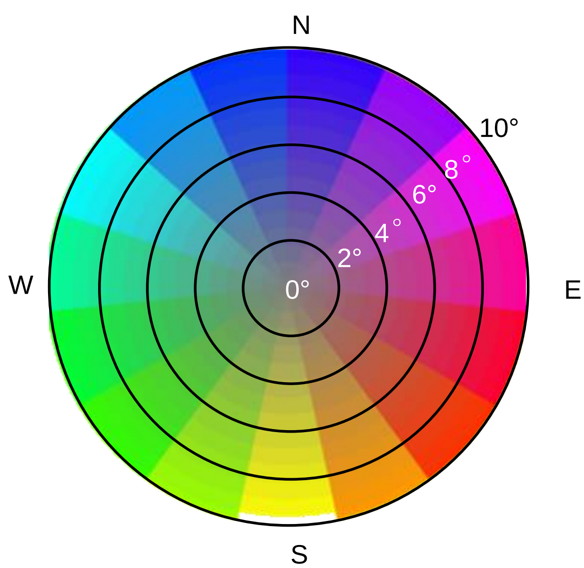
Note in each constant lightness plane the four levels of saturation (where the lowest, zero saturation level is gray) and the 12 levels of hue, which wrap around.

The 3D color wheel (when the attribute plotted against hue is cyclic)

Because the colorbar used for the hue axis is cyclic, the software knows to plot it as a color wheel (or cylinder in three dimensions):

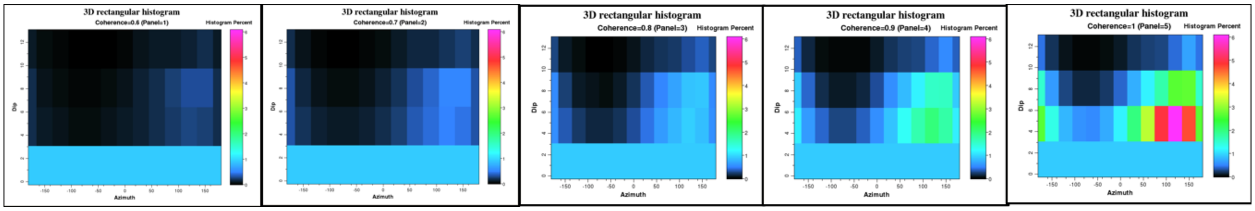


The color wheels are plotted using the **aaspi_plot** utility which is designed to display seismic amplitude and attribute data. I've annotated the image in PowerPoint to give a more explicit definition of the color wheel:



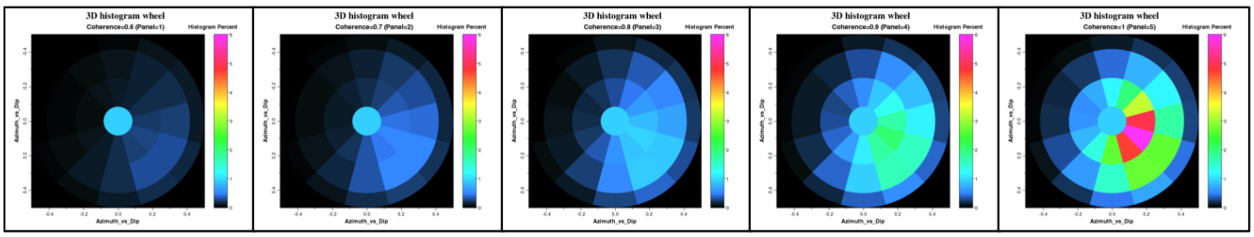
3D histograms

As part of the color display, each triplet is assigned to a bin (which range from a value of 0 to a value of *max_color*-1). It is therefore a simple matter to define how many voxels map to a given bin, giving a 3D histogram.



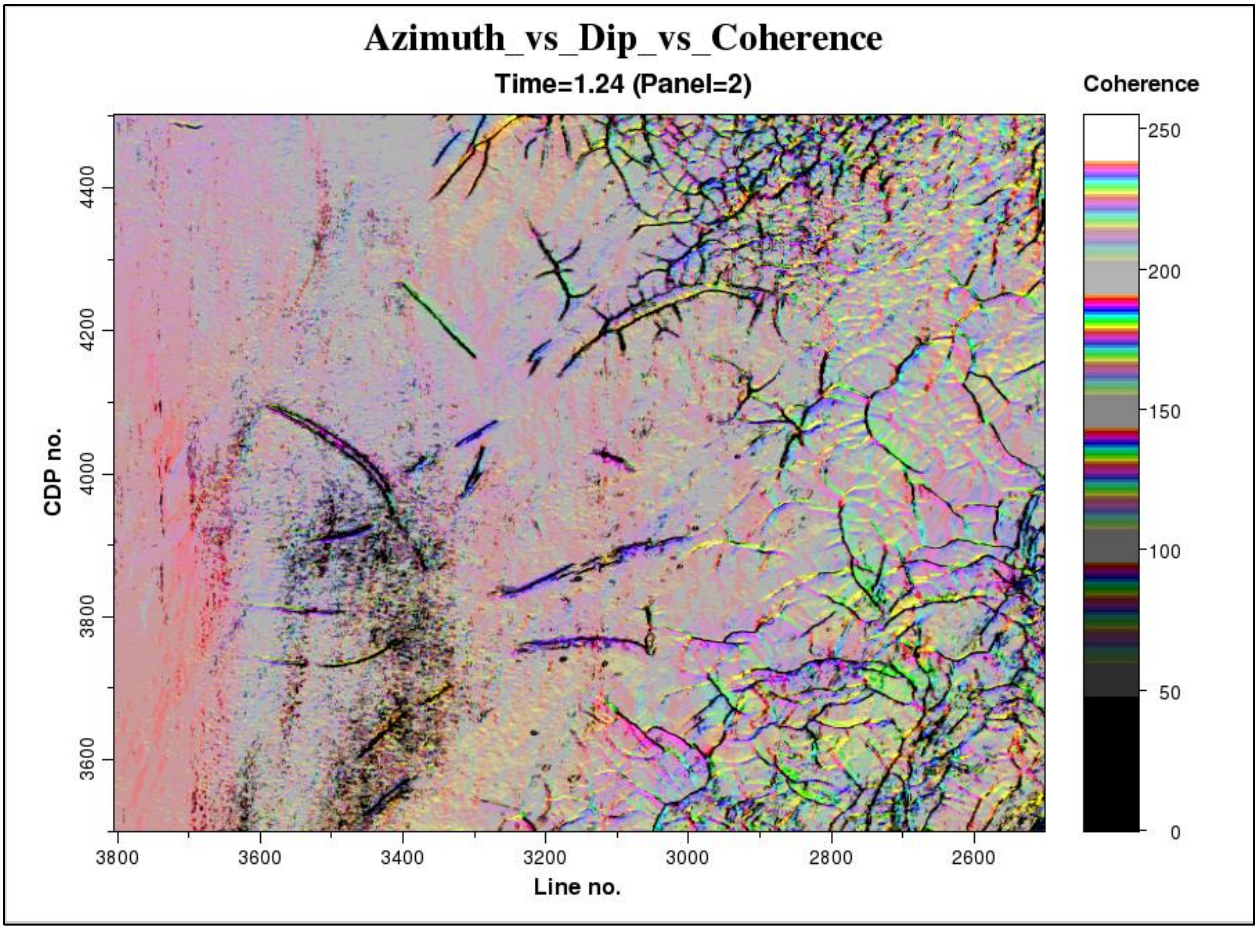
3D histogram wheels

When an attribute is plotted against saturation using cyclic color bar, program hlsplot will also plot the histogram as a series of wheels. In this image we see that the most common orientation exhibits high coherence and dipping gently to the Southeast.



Plotting the composite image

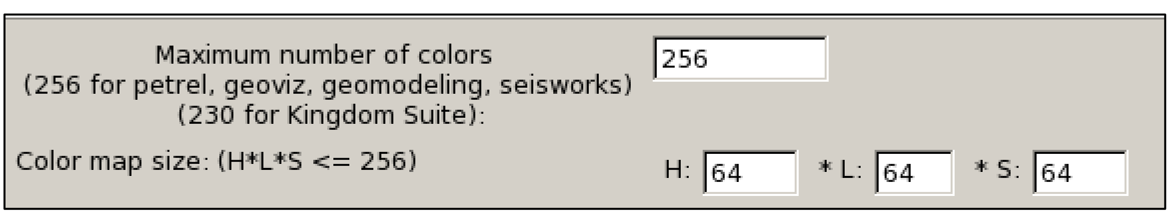
The **hlsplot** python script will using program crop to decimate the data vertically and slice to generate time slices to quality control the results. Here is a representative time slice using the parameters shown in the GUI above:



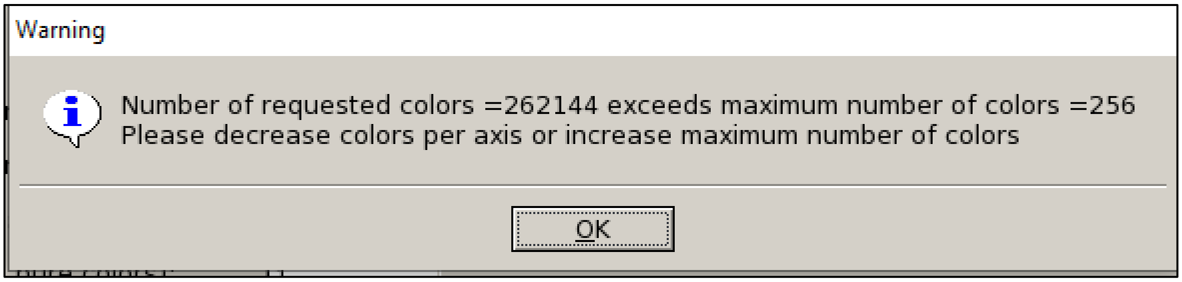
Adding greater color depth

The default settings will be set to give 240 colors which can be loaded into almost all commercial interpretation software packages. However,

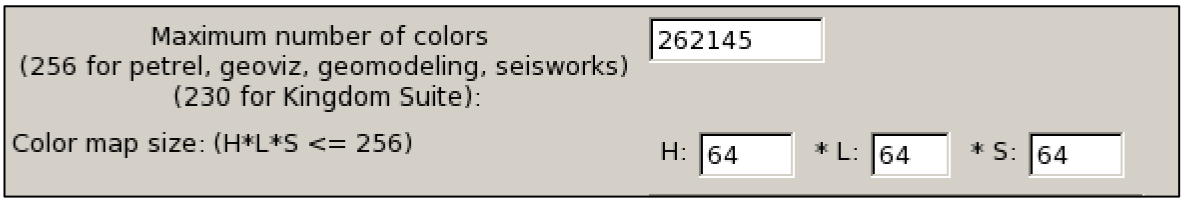
Now, lets change the number of colors on each axis to be 64:



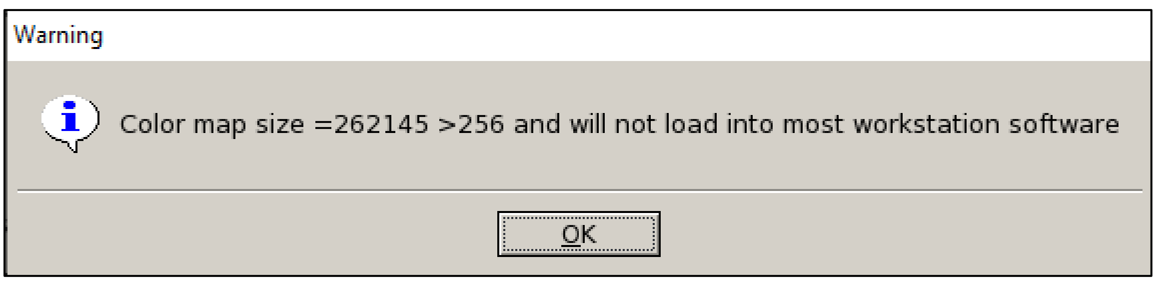
When I execute the program, I obtain a warning message that requires me to change the maximum number of colors



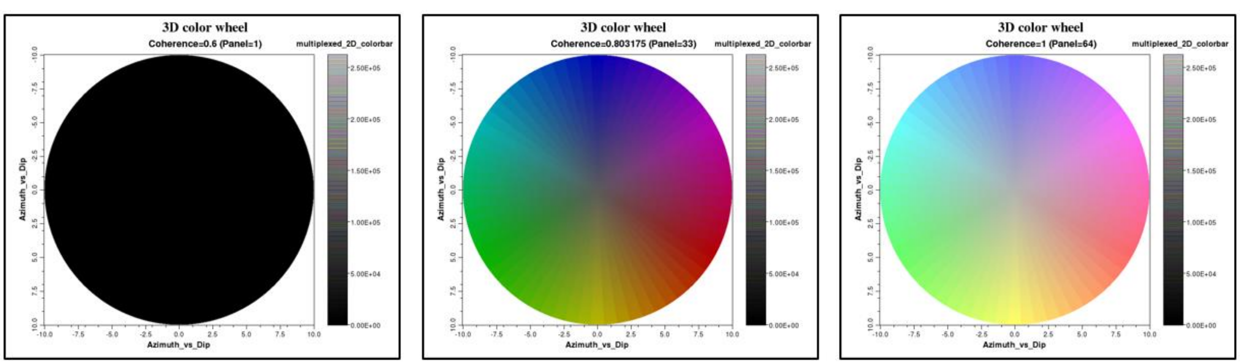
where 64×64×64=262,144. I need to add one extra color for background white, so my GUI now looks like this:



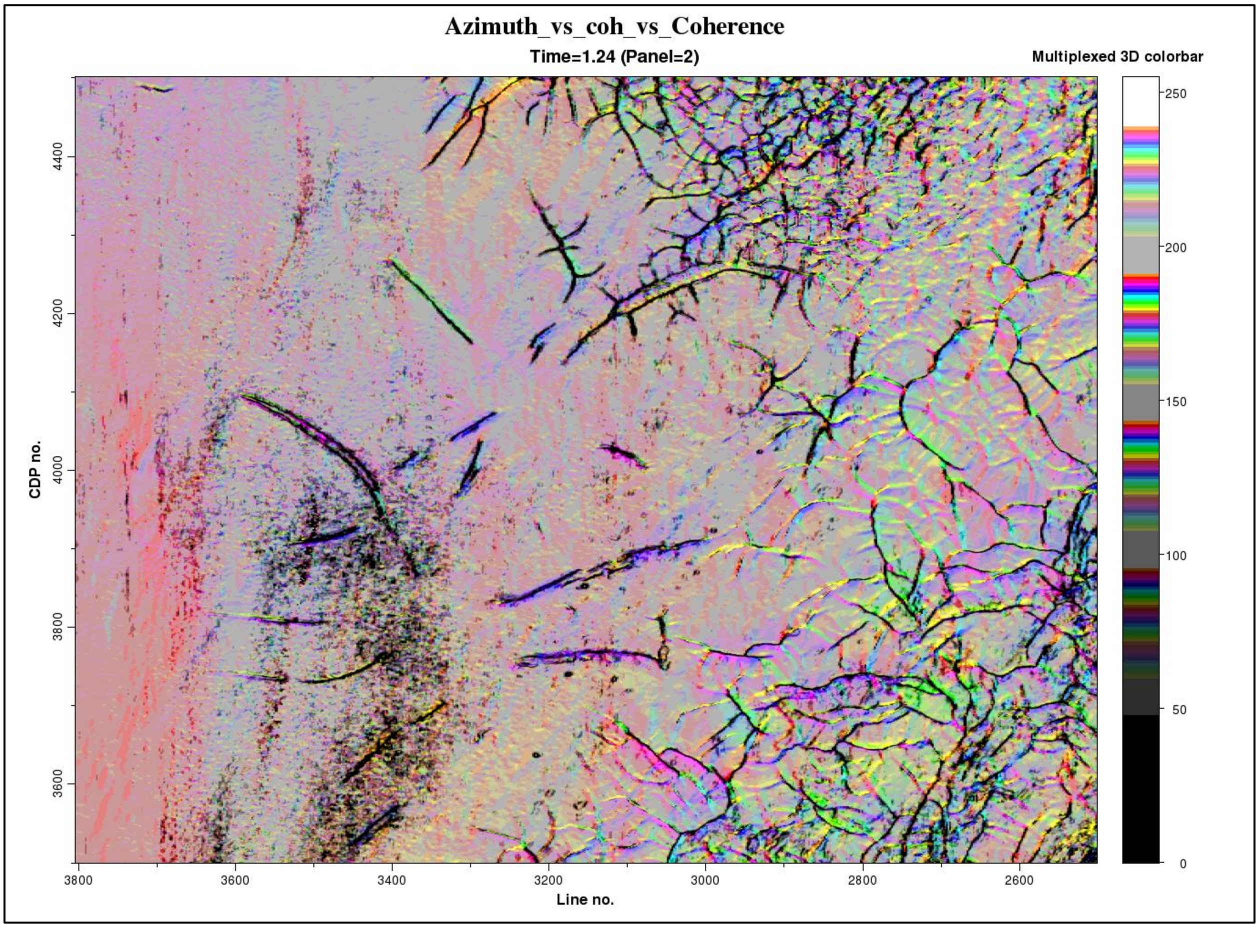
I get one more warning message which I can simply ignore:



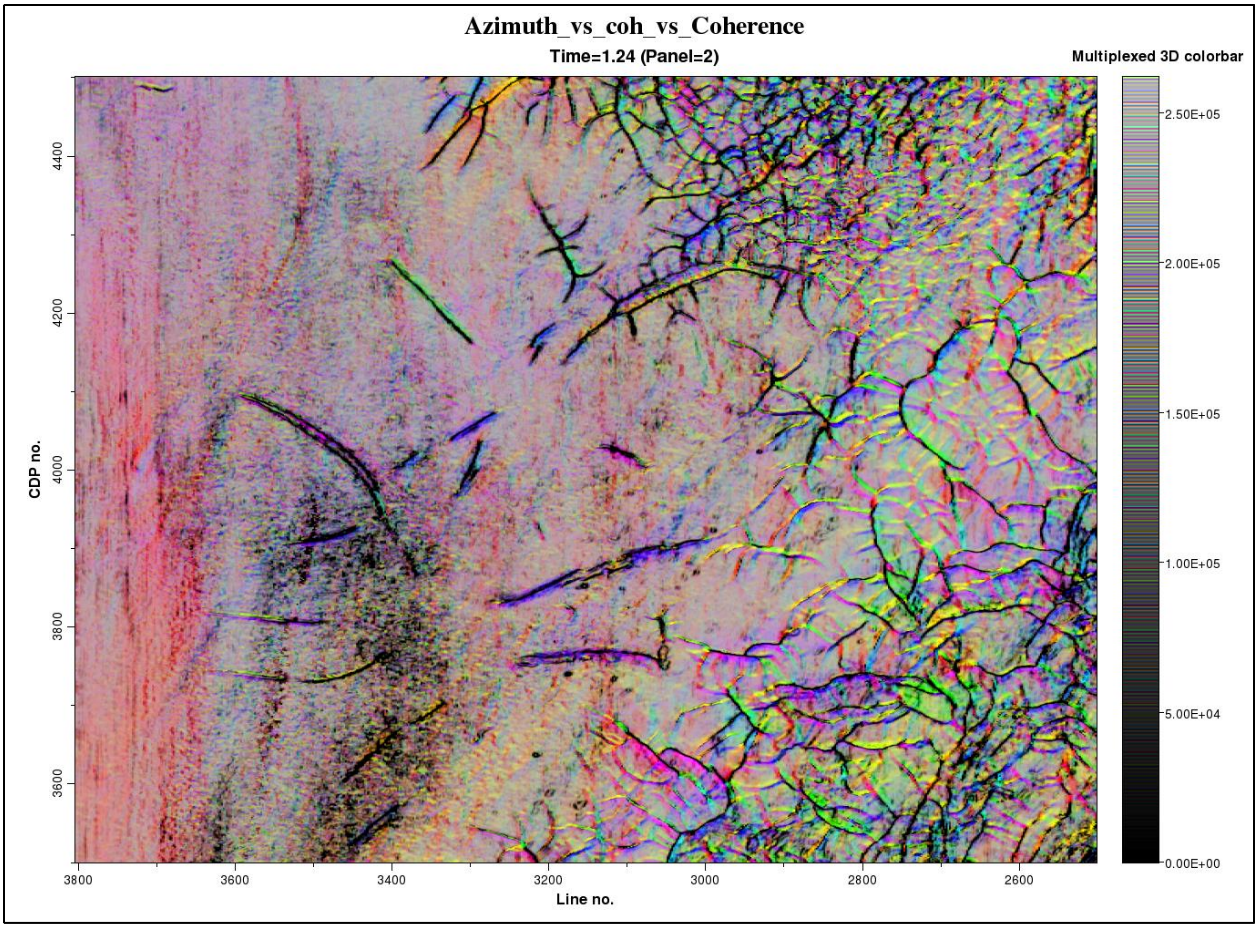
My new 3D color bar and color wheel (cylinder) now has 64 panels. I ‘ll plot those corresponding to coherence values of 0.6, 0.8, and 1.0:



Let's now examine the impact of changing the color depth. Here is a time slice of the three attributes plotted using 240 colors (the 16 remaining colors were white)



And the same time slice when using 262,145 colors



The best way to compare the two images it to animate between them. There is a significant improvement in lateral resolution of small details provided by the extra levels of coherence and dip magnitude (lightness and saturation).

References

Marfurt, K. J., 2015, Techniques and best practices in multiattribute display: Interpretation, **3**, 1-24.